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Considering Fixed-Mobile Convergence Service as a Two-Sided Market

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Abstract: This paper considers the rapidly developing fixed-mobile convergence (FMC) service as a two-sided market and analyzes the price structure à la Bertrand-Nash based on revealed preference data. The price structure is calculated such that the price-cost margin is higher for NTT's relatively advantageous fixed-line Internet service and lower for NTT's relatively disadvantageous mobile phone service, both of which have the largest market shares in their respective markets.
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1. Introduction

This paper analyzes the *fixed-mobile convergence (FMC) service* as a two-sided market. A two-sided market is defined as a market in which one or several platforms enable interactions between end-users and try to get the two sides "on board" by appropriately charging each side (Rochet and Tirole 2003, Armstrong 2006). Consider a platform that requires per-interaction charges (a^A and a^B) from both sides. The market is one-sided if volume V of transactions realized on the platform depends only on the aggregate price level:

$$a = a^A + a^B,$$

i.e., V is insensitive to reallocations of the total price a between the two sides. If, in contrast, V varies with a^A while a remains constant, the market is said to be two-sided (Rochet and Tirole 2006 pp. 645-648).

One example of a two-sided market is a credit card: for a given set of charges, a consumer is more likely to use a credit card that is widely accepted by retailers, while a retailer is more likely to accept a card that is carried by many consumers. See Rochet and Tirole (2003) for further examples of two-sided markets (Table 1).

<Table 1>

Japan's fixed-line Internet and third generation (3G) mobile phone services have developed rapidly, blazing a trail for others in the world to follow (Ida 2009). As of March 2009, the number of subscriptions to fixed-line Internet (broadband) services was 30 million (household penetration rate of about 50%), broken down as fiber to the home (FTTH) service (50%), asymmetric digital subscriber line (ADSL) service (37%), and cable modem (CATV) Internet service (14%). An analysis of the market share of Internet providers shows that NTT gained 36% and 74% in the ADSL and FTTH markets, respectively. On the other hand, the number of contracts for mobile phones in Japan had reached 120 million by March 2009, and the mobile Internet penetration rate is almost 90%. Note that 3G users now overwhelmingly exceed 2G users. The market share figures for mobile phone providers are 49% for NTT, 28% for KDDI, and 18% for Softbank.

At this moment, FMC service, which is expected to spread extensively in the near future (Curwen 2006), can be classified into the following three categories:

- One charge system: Customers benefit from discounted one-stop billing services.
- One handset (or equipment): Customers can make telephone calls with one telephone and one number.
- One network: Providers can provide enhanced services with one database and one seamless network.

From top to bottom, consumers enjoy increased value addition, whereas providers have to shoulder the burden of increased development costs. Note that the most enhanced FMC service assumes advanced customers will use both services; only NTT, KDDI, and Softbank can provide both FTTH and 3G services. The NTT group's services have the largest market shares in both the FTTH and 3G markets, raising serious concerns for promoting effective competition. For example, in June 2008, the NTT group started to provide a new FMC service called "Home U" that uses a new handset called "Onefone"; this service can be used for both mobile phones and wireless LANs and allows users to freely use their mobile Internet service at home if they pay a monthly fee of JPY 1,029 (US$ 10)[1].

Consider FMC service as a two-sided market. In two-sided markets, there are two different types of users at both ends of a common platform. For FMC service, the platform provider is a telecommunications carrier that supplies both fixed-line Internet and mobile phone services. The carrier sets its price structure, which comprises fixed-line Internet and mobile phone prices, to maximize joint profit. Because of indirect network effects, an increase in fixed-line Internet users increases mobile phone users on the same platform through an increase in the number of partners and the variety of FMC services. The reverse is also true. In Japan, the following carriers provide both fixed-line Internet and mobile phone services: NTT, KDDI, and Softbank. They oligopolistically compete by considering the two-sidedness of FMC service[2].

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[1]British Telecom (BT) started an FMC service called "BT Fusion" in June 2005. This service made it possible to use one handset as an IP phone at home (via Bluetooth or Wi-Fi) and as a mobile phone outdoors.

[2]Previous studies have pointed out that fixed-line and mobile phone services are two-sided. "Interestingly, even mobile and fixed telephone services, for which most

The following is a summary of our study's main aims and conclusions. We analyze the price structures of fixed-line Internet and mobile phone services for subscribers to both services. Even though the Japanese FMC service is relatively new, we assume that the carriers determine their profit-maximizing price structures by considering its two-sidedness. We propose a model where indirect network effects exist between the fixed-line Internet and mobile phone users and where FMC carriers are oligopolistically competing in a differentiated Bertrand fashion. We estimate the price parameters and the network effect parameters using data that we collected in a consumer survey that was jointly conducted by the Ministry of Internal Affairs and Communications (MIC) and Kyoto University in March 2009. Based on our estimates, we calculate the equilibrium margins for fixed-line Internet and mobile phone services and discuss firms' strategies and competition policies for future FMC service.

At this point, we should explain the network effect in a two-sided market. Users enjoy more telecommunications conversations at reduced rates and benefit from more diverse content by integrating the brands of fixed-line Internet and mobile phone services. However, FMC continues to develop, and the network effects of FMC service are expected to grow due to such improvements. Therefore, consumer preferences are dynamically changing, and this research is a tentative estimation based on current preferences.

Note that not all fixed-line users subscribe to the same brand of mobile phone service, and not all mobile phone users subscribe to the same brand of fixed-line service. Therefore, the equilibrium consumer surplus and profits depend on the price structures determined by the platform carriers.

When considering FMC service as a two-sided market, we observe that 270 users (43%) out of the total number of NTT users (622 users) subscribed to fixed-line Internet and mobile phone services of the same brand, but the remaining 352 users (57%) subscribed to different brands. Similarly, 88% of KDDI and 81% of Softbank users did

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users are both callers and receivers, should be treated as two-sided markets. A high termination charge raises the marginal cost of calls and lowers the marginal cost of call receptions. In other words, the termination charge is an instrument of cross-subsidization similar to the interchange fee in credit card markets" (Rochet and Tirole, 2003, p.1018).

not integrate brands. Therefore, most users do not integrate two brands at both ends of a platform, and the platform carriers cannot completely internalize the network effects by charging two-ended users. This is the reason we consider FMC service a two-sided market.

Two main conclusions are obtained in this paper. First, network effects and two-sidedness exist between fixed-line Internet and mobile phone services. In other words, an increase in market share on one side increases the market share on the other side of the same platform. Across different platforms, in contrast, an increase in market share on one side decreases the market share on the other side. Second, we calculated the equilibrium price structure given this two-sidedness. For NTT, whose services have the largest market shares in both markets, the margin is set higher in the former market and lower in the latter. NTT profits by subsidizing its relatively disadvantageous market using its relatively advantageous market. Softbank subsidizes its mobile phone services with fixed-line Internet, and KDDI does the opposite.

This paper is organized as follows. Section 2 explains the survey method and data. Section 3 proposes a generic model of a two-sided market according to Argentesi and Filistrucchi (2007), and Section 4 explains a suitable estimation model for the two-sidedness between fixed-line Internet (broadband) and mobile phone services. Then, Section 5 demonstrates the estimation results, and Section 6 provides optimal price structures and discusses the various implications of strategies and policies. Section 7 contains our concluding remarks.

2. Survey Method and Data

In March 2009, in a joint effort with MIC, we conducted a sample survey on the individual usage of telecommunications services. Random surveys were conducted on monitors registered with a consumer monitor investigation company. We identified 786 individuals currently using both fixed-line Internet and mobile phone services. The survey included such socio-demographics as gender, age, occupation, and household income (Table 2). While carrying out this random sampling, we carefully considered Japan's geographical characteristics, gender breakdowns, and age structures.

<Table 2>

The breakdowns are given in Table 3 based on fixed-line Internet (broadband) usage. The selection ratios are 39% for ADSL and 61% for FTTH [3]. NTT's market share is 36% for ADSL and 82% for FTTH. The current major Internet usages are indicated in Table 4. The 050-type IP phone (whose service qualities such as voice clearness are not guaranteed) are popular among ADSL users (38%), and the 0ABJ-type IP phone (whose qualities of service are guaranteed) are rather popular in FTTH (10%). There is no significant difference between ADSL and FTTH with regard to free or paid downloads of music and movies.

<Table 3>

<Table 4>

The details of mobile phone usage are given in Table 5[4]. The selection ratios are 9% for 2G and 91% for 3G. This means that mobile-phone migration from 2G to 3G has almost finished in Japan. Market shares are 49% for NTT, 25% for KDDI, and 25% for Softbank. The current major function usages are indicated in Table 6. Note that overall, from basic services (e.g., sending/receiving e-mail and browsing the Web) to advanced services (e.g., viewing movies and carrying out financial transactions), the service usages by 3G users are superior to those by 2G users.

<Table 5>

<Table 6>

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[3]To focus on the three carriers (NTT, KDDI, and Softbank) that provide fixed-line Internet and mobile phone services, we dropped CATV Internet users from the samples. This assumption can be partly rationalized by the independently and identically distributed (IID) assumption described later on in this paper.

[4]Note that KDDI's market share is smaller than the actual figure. This is because initial KDDI users did not notice that they were already 3G users. We did not correct the data because the 2G market share was so small that we could simply ignore the influence.

3. Theoretical Models

Following Rochet and Tirole (2003) and Armstrong (2006), many theoretical models of two-sided markets have been proposed. Table 7 summarizes these developments. We adopted a generic model of a two-sided market that was initially proposed by Argentesi and Filistrucchi (2007). Assume that multiple platforms compete in a differentiated Bertrand fashion. Each group values the size (number, share, variety, and so on) of the opposite group on the same platform.

<Table 7>

Assume N^F users in the fixed-line Internet market; it is given that the utility of subscribing to carrier i ($i = 1,2,...,n$) linearly increases with the number of mobile phone users of the same platform (N_i^M) and decreases its price (p_i). Allowing for other observable variables to the utility (X_i^F) and a mean-zero IID error term (ε_i^F), the utility can be written as $U_i^F = X_i^{F'}\beta^F - \alpha^F p_i^F + \gamma^F N_i^M + \varepsilon_i^F$. The model considers that the utility for fixed-line Internet (U_i^F) depends positively on the scale (and potentially the variety) of mobile phone markets on the same platform (N_i^M). The converse holds true for the utility of mobile phone service U_i^M.

Turning to the supply side, we derive the pricing equation under the hypothesis that carriers are competing à la Bertrand-Nash. The total profit function of carrier i can be written as:

$$\Pi_i(p_i^F, p_i^M) = (p_i^F - c_i^F)y_i^F(P^F, Y^M(P^M)) + (p_i^M - c_i^M)y_i^M(P^M, Y^F(P^F)),$$

where p_i^F is the price of fixed-line Internet i and y_i^F is its demand, which depends on the vector of fixed-line Internet prices ($P^F = (p_1^F, p_2^F, ..., p_n^F)$) and on the vector of mobile phone demands ($Y^M = (y_1^M, y_2^M, ..., y_n^M)$), which in turn depend on the mobile phone prices $(P^M = (p_1^M, p_2^M, ..., p_n^M))$. For mobile phones, p_i^M is the price of mobile phone service i, and y_i^M is the corresponding demand, which depends on the vectors of mobile phone prices (P^M) and fixed-line Internet demands ($Y^F = (y_1^F, y_2^F, ..., y_n^F)$), which in turn depend on the fixed-line Internet prices (P^F). Under the assumption of constant marginal costs, c_i^F and c_i^M are the marginal costs of the fixed-line Internet and mobile phone services, respectively.

Each carrier providing an FMC platform chooses a fixed-line Internet price (p_i^F) and a mobile phone price (p_i^M) to maximize their total profit (Π_i), taking other firms' prices (p_j^F, p_j^M) as given. For each carrier *i*, there are two first-order conditions (FOC):

- FOC for the fixed-line Internet margin is derived from the total profit maximization with respect to p_i^F:

$$p_i^F - c_i^F = -\frac{y_i^F}{\partial y_i^F / \partial p_i^F} - (p_i^M - c_i^M)(\frac{\partial y_i^M}{\partial y_i^F} + \frac{1}{\partial y_i^F / \partial p_i^F} \sum_{i \neq j} \frac{\partial y_i^M}{\partial y_j^F} \frac{\partial y_j^F}{\partial p_i^F})$$

- FOC for the mobile phone margin is derived from the total profit maximization with respect to p_i^M:

$$p_i^M - c_i^M = -\frac{y_i^M}{\partial y_i^M / \partial p_i^M} - (p_i^F - c_i^F)(\frac{\partial y_i^F}{\partial y_i^M} + \frac{1}{\partial y_i^M / \partial p_i^M} \sum_{i \neq j} \frac{\partial y_i^F}{\partial y_j^M} \frac{\partial y_j^M}{\partial p_i^M})$$

The price-cost margin is lower in two-sided markets than in one-sided markets because of the network effect between the fixed-line Internet and mobile phone services. This network effect is captured by the last two terms on the right-hand side. The first term expresses that a price increase decreases its own demand, thus decreasing the mobile phone demand on the same platform ($\partial y_i^M / \partial y_i^F$). The second term represents the competition effect: a price increase for fixed-line Internet *i* increases the demand for a rival service ($\partial y_j^F / \partial p_i^F$) and has a negative effect on its mobile phone demand ($\partial y_i^M / \partial y_j^F$). The margin ($p_i^F - c_i^F$) can be computed on the basis of the estimated parameters of the logit models described below. The same can be said of the mobile phone margin ($p_i^M - c_i^M$).

4. Estimation Models

Several important empirical papers analyzing two-sided markets have recently been published (Table 8). Next, we explain an estimation model that measures the two-sidedness between fixed-line Internet (broadband) and mobile phone services.

<Table 8>

Among the Japanese telecommunications carriers, the NTT group extensively provides fixed-line Internet services, including FTTH, and mobile phone services, including 3G. In this respect, the NTT group can raise its competitiveness by registering more users to both services. That is, users who subscribe to NTT's broadband services are more likely to subscribe to NTT's mobile phone services. Users who subscribe to NTT's mobile phone services are also more likely to subscribe to NTT's broadband services. The same thing applies to KDDI and Softbank, except that when compared with NTT, their shares are much smaller in both markets.

Next, we consider a simultaneous-equation model and address the problem of endogeneity across those equations. The full-information maximum likelihood (FIML) method, which jointly treats all equations and all parameters, is the most efficient among the estimators. However, since the FIML estimator requires immense computations, it is often difficult to perform. Instead, the limited-information maximum likelihood (LIML) method can be considered. We used the two-stage logit estimation method that consists of the following procedure (Maddala 1983). First, we separately estimated the reduced-form equations via the logit model, using all exogenous variables such as monthly fixed prices. Second, we estimated the structural-form equations via the logit model and inserted expected choice probabilities as instrumental variables into the model.

The *reduced*-form equations are indicated as follows:

$$Y_i^F = 1 \quad \{\sum_{k=F,M} X_i^{k\prime}\beta^{Fk} - \sum_{k=F,M} \alpha^{Fk} p_i^k + \varepsilon_i^F > \sum_{k=F,M} X_{j\neq i}^{k}{}'\beta^{Fk} - \sum_{k=F,M} \alpha^{Fk} p_{j\neq i}^k + \varepsilon_{j\neq i}^F\}$$

$$Y_i^M = 1 \quad \{\sum_{k=F,M} X_i^{k\prime}\beta^{Mk} - \sum_{k=F,M} \alpha^{Mk} p_i^k + \varepsilon_i^M > \sum_{k=F,M} X_{j\neq i}^{k}{}'\beta^{Mk} - \sum_{k=F,M} \alpha^{Mk} p_{j\neq i}^k + \varepsilon_{j\neq i}^M\},$$

where Y_i^F denotes the discrete choice of subscribing to fixed-line Internet service *i* and Y_i^M denotes the discrete choice of subscribing to mobile phone service *i*. 1 {-} is an indicator function that reflects whether the terms in the brackets are true. X_i^F and X_i^M are exogenous variables; p_i^F and p_i^M are monthly fixed prices, which we assume to be predetermined for individuals; α^{kl} and β^{kl} are parameters to be estimated (*k, l = F, M*); ε_i^F and ε_i^M are IID extreme value (EV) random terms.

The *structural*-form equations are indicated as follows[5]:

[5]Correction of the asymptotic covariance matrix at the second step requires additional

$$Y_i^F = 1 \quad \{X_i^{F\prime}\beta^F - \alpha^F p_i^F + \gamma^F \tilde{N}_i^M + \varepsilon_i^F > X_{j\neq i}^{F\,\prime}\beta^F - \alpha^F p_{j\neq i}^F + \gamma^F \tilde{N}_{j\neq i}^M + \varepsilon_{j\neq i}^F\}$$

$$Y_i^M = 1 \quad \{X_i^{M\prime}\beta^M - \alpha^M p_i^M + \gamma^M \tilde{N}_i^F + \varepsilon_i^M > X_{j\neq i}^{M\,\prime}\beta^M - \alpha^M p_{j\neq i}^M + \gamma^M \tilde{N}_{j\neq i}^F + \varepsilon_{j\neq i}^M\}.$$

We define that $\tilde{N}_i^M = \tilde{P}_i^M S_i^M$, given that $\tilde{P}_i^M$ denotes the expected choice probability of subscribing to the mobile phone service of identical carrier *i* and measures the willingness to use the FMC service provided by carrier *i*, while S_i^M denotes the market share of the mobile phone service of carrier *i* and measures the attractiveness of the FMC service provided by carrier *i*. The same definition applies to $\tilde{N}_i^F = \tilde{P}_i^F S_i^F$. γ^F and γ^M are parameters that represent the network effects if users subscribe to both the fixed-line Internet and mobile phone services provided by identical carrier *i*.

5. Estimation Results

In this section, we demonstrate the estimation results and calculate the marginal effects. We adopted the two-stage logit estimation method that was explained in the previous section. The explained variables are the Japanese telecommunications carriers that provide both fixed-line Internet and mobile phone services: NTT, Softbank, and KDDI. Table 9 summarizes the basic statistics of the sample used for our analysis. The market shares of the fixed-line Internet service are NTT (64%), Softbank (25%), and KDDI (10%). Note that 78% of NTT's fixed-line Internet users subscribe to the FTTH service. On the other hand, almost all of Softbank's fixed-line Internet users subscribe to ADSL, and all KDDI users subscribe to FTTH. The mobile phone shares are 49% for NTT and 25% for KDDI and Softbank. These numbers are actually different from the real figures (KDDI 30% and Softbank 20%) because we focused on the users who subscribe to both services and excluded all others. Many KDDI users are young and actively download music/movie data via mobile Internet and do not use fixed-line Internet at home.

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computation (Murphy and Topel, 1985).

<Table 9>

The prices are the cheapest for Softbank in both fixed-line Internet and mobile phone services, which is consistent with our expectation that Softbank has gained market shares with its inexpensive introductory prices. Interestingly, the prices are highest for KDDI for both services, perhaps because its fixed-line Internet users subscribe to the expensive FTTH service and its mobile users download expensive data.

Users who integrate both fixed-line Internet and mobile phone brands are the most likely to use advanced FMC services: their ratio to the total users is 34% for NTT, 8% for Softbank, and 4% for KDDI. NTT users are the most promising candidates for FMC services. In this respect, NTT will increasingly enjoy an advantage over its competitors as FMC service spreads.

Based on the estimates of monthly fixed prices and network effects, we calculated their marginal effects. Then, based on those marginal effect values, we can draw the equilibrium margins for fixed-line Internet and mobile phone services. We can also control for other individual characteristics such as age, gender, household income, family composition, Internet usage (ADSL subscription, music download, movie streaming, IP phone, on-line games, on-line shopping, on-line banking, blogs, etc.), and mobile phone usages (3G subscription, picture download, movie streaming, game applications, e-books, GPS, international roaming, etc.).

Let us examine the estimation results of fixed-lined Internet service (Table 10). As expected, the monthly fixed price of fixed-line Internet service negatively influences the choice probability of fixed-line Internet service with 1% significance, and a network effect exists from mobile phones to fixed-line Internet with 1% significance. Furthermore, among control variables, the following are statistically significant: NTT's user ages, NTT's ADSL dummy, NTT's on-line shopping, and Softbank's IP phone[6].

Next, we turn to the estimation results of mobile phone services. As expected, their monthly fixed price negatively influences the choice probability of mobile phone carriers with 1% significance, and a network effect exists from fixed-line Internet to mobile phones with 1% significance. Furthermore, among control variables, the

[6]Estimates of individual characteristics represent the incremental utility of choosing NTT or Softbank based on KDDI's utility.

following are statistically significant: NTT's mobile music download, NTT's GPS, Softbank's mobile music download, and Softbank's GPS.

<Table 10>

On the basis of the estimates for the monthly fixed prices and network effects, the marginal effects can be calculated (Table 11)[7]. For fixed-line Internet, an increase in NTT's fixed-line Internet price decreases its choice probability by 0.000041. This is its own marginal effect of choice probability with its fixed-line Internet price. Increases in Softbank's and KDDI's fixed-line Internet prices increase the choice probabilities of NTT's fixed-line Internet service by 0.000027 and 0.000014, respectively. They are the cross marginal effects of the choice probabilities of NTT's fixed-line Internet service with Softbank and KDDI's fixed-line Internet prices.

For mobile phone network effects, an increase in NTT's mobile phone share increases the choice probability of NTT's fixed-line Internet by 0.68. This is its own marginal effect of the choice probability of NTT's fixed-line Internet with its mobile phone share. Increases in Softbank's and KDDI's mobile phone shares decrease the choice probabilities of NTT's fixed-line Internet service by 0.45 and 0.23, respectively. They are the cross marginal effects of the choice probabilities of NTT's fixed-line Internet with Softbank's and KDDI's mobile phone shares. All other interpretations are the same.

<Table 11>

We summarize the main points as follows.

FINDING 1: Network Effects

An important feature of two-sided markets is the network effect. We expectedly see that network effects exist between fixed-line Internet and mobile phone markets. An increase in one market share increases the other market share on the same platform. On the other hand, an increase in one market share decreases the other

[7]The values of marginal effects are ordinarily very small and are multiplied by 100.

market share across different platforms.

It is interesting to examine how network effects vary across platforms (NTT, Softbank, and KDDI). The own marginal effects of the network effects from mobile phone to fixed-line Internet are 0.69, 0.59, and 0.37 for NTT, Softbank, and KDDI, respectively. The own marginal effects of the network effects from fixed-line Internet to mobile phone are 0.28, 0.22, and 0.22 for NTT, Softbank, and KDDI, respectively. NTT's figures are the highest in both cases. This implies that NTT can easily gain market share via bidirectional network effects since it has the largest market shares in both the fixed-line Internet and mobile phone markets. Softbank benefits from reasonable network effects that do not compare with those of NTT[8]. KDDI's market share in fixed-line Internet is so small that its network effect from mobile phone to fixed-line Internet is not effective. When these carriers try to lock-in users by enriching FMC services, NTT has a competitive advantage over Softbank and KDDI.

6. Discussions

The economics of two-sided markets differ from those of one-sided markets in the following respects (Evans 2003). First, any change in demand or cost on one market will affect the price structure and the total price. Furthermore, there is no necessary relationship between price and marginal cost on either side. In fact, the price on one side could be above marginal cost, while the price on the other side could be below.

Considering FMC service as a two-sided market, we calculated the equilibrium price structures. The margin of a two-sided market can be divided into two parts: its own price effect term and the network effect term, the latter of which is the multiplication of the margin on the other market and the network effect parameter. Since the network effect coefficient is negative, a carrier decreases its price by the network effect term. The calculated equilibrium margins are indicated in Table 12.

<Table 12>

[8]Note that most Softbank fixed-line Internet users subscribe to ADSL, and therefore Softbank's network effects will decrease as migration from ADSL to FTTH advances.

The equilibrium margin of fixed-line Internet service is calculated as follows: JPY 15,671 (US$ 157) (NTT's fixed-line Internet share divided by its own marginal effect of price) minus JPY 435 (US$ 4) (NTT's mobile phone margin, JPY 1,027 (US$ 10), multiplied by the network effect parameter, –0.4235) equals JPY 15,236 (US$ 152). The network effect term is so small that the difference in price is rather small if we consider the two-sidedness. The equilibrium margin of mobile phone service is calculated as follows: JPY 13,297 (US$ 133) (NTT's mobile phone share divided by its own marginal effect of price) minus JPY 12,270 (US$ 123) (NTT's fixed-line Internet margin, JPY 15,236 (US$ 152), multiplied by the network effect parameter, -0.8053) equals JPY 1,027 (US$ 10). The network effect term is so large that the difference in price is huge if we consider the two-sidedness.

The following is the reason for such stark price differences. The network effect parameter from fixed-line Internet to mobile phone is small, while the margin is small for a mobile phone user; therefore, it is less profitable to gain fixed-line Internet users by decreasing the price. Conversely, the network effect parameter from mobile phone to fixed-line Internet is large, while the margin is large for fixed-line Internet users; therefore, it is very profitable to gain mobile phone users by decreasing the price. This divergence between the fixed-line Internet and mobile phone margins results from the two-sidedness of FMC service.

As for Softbank and KDDI, the equilibrium margins reflect their advantages and disadvantages. Softbank's margin is higher for fixed-line Internet (JPY 6,167, US$ 62) than for mobile phones (JPY 3,077, US$ 31), and KDDI's margin is lower for fixed-line Internet (JPY 2,180, US$ 22) than for mobile phones (JPY 7,552, US$ 76).

We summarize the main points as follows.

FINDING 2: Price Structures

Price structures reflect network effects in two-sided markets. Since NTT has the largest market shares in both the fixed-line Internet (especially FTTH) and mobile phone markets, NTT strategically sets its margin higher in the fixed-line Internet market and sets its margin lower in the mobile phone market to maximize its total profit by subsidizing the relatively disadvantageous market (mobile phones) with the relatively advantageous market (fixed-line Internet). Similarly, Softbank subsidizes its mobile phone markets with fixed-line Internet, and KDDI subsidizes its fixed-line Internet with mobile phones.

We will now supplement the above finding in some respects. First, the calculated price structures are very different from the actual observed price structures. The actual price-cost margin levels of fixed-line Internet and mobile phones are much lower than those calculated from the estimation results, and thus the carriers do not significantly subsidize the relatively disadvantageous markets with the relatively advantageous markets. Although deregulation has steadily progressed in the telecommunications industry, a bottleneck monopoly remains in subscriber access lines. Therefore, NTT is strictly regulated to open its essential facilities (including optical fiber) to competitors, and it cannot freely set profit-maximizing prices by considering two-sidedness. Next, to promote competition in the telecommunications industry, NTT is structurally unbundled under the holding company system and is prohibited from doing business jointly within group companies; it cannot freely set a profit-maximizing price structure by considering two-sidedness (e.g., between fixed-line Internet and mobile phone services). Last, broadband services, particularly FTTH, are still expanding, and each carrier is adopting introductory pricing by lowering its margins.

Second, as stated above, the carriers cannot freely set their price structures by considering two-sidedness due to Japan’s strict competition policy, but we expect that radical changes in price structure will occur if the carriers are allowed to freely set prices. NTT will raise its price-cost margin in the relatively advantageous fixed-line Internet market (up to JPY 15,236, US$ 152) and lower it in the relatively disadvantageous mobile phone market (to JPY 1,027, US$ 10); the total price-cost margin level becomes JPY 16,263 (US$ 163), which is very high compared with the price-cost margins of its competitors. NTT, which has an overwhelming market share in the fixed-line Internet market, has a great advantage over Softbank and KDDI. NTT’s dominance is expected to increase in the future because of the network effects of two-sidedness.

In summary, it is difficult for other carriers to compete effectively with NTT by supplying two-sided FMC services. In order to promote competition, the government should limit NTT's provision of FMC services and require it to unbundle an efficient component so that other carriers can provide FMC services.

7. Conclusions

FMC services, which are based on the most advanced fixed-line and wireless networks in the world, are expected to spread extensively in Japan. This paper analyzed the two-sidedness of FMC service based on consumer-revealed preference data. NTT, Softbank, and KDDI are the major providers of FMC services. In this paper, we assumed that carriers compete à la Bertrand-Nash and estimated the prices and network effect parameters. We then substituted these estimates into the equilibrium price structures of two-sided FMC services.

However, many unsolved problems remain. First, although FMC services are characterized by their two-sidedness, they are still being diffused. We must investigate these features in more detail. We anticipated the future price structures of FMC services on the basis of the current fixed-line Internet and mobile phone demand systems. Second, we assumed that the competition model operated à la Bertrand-Nash and scrutinized the equilibrium price structures. Naturally, our results are dependent on these assumptions, and we should examine the model settings to check the robustness of our results. Third, we investigated the price structures of fixed-line Internet and mobile phones, but consumer preferences are rapidly changing, which is reflected in the development of FMC services. We must carefully continue to track such changing preferences. These important topics shall be considered in our future research.

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Table 1: Examples of two-sided markets

Product	Subsidized segment	Subsidizing segment
	(a) Software industries	
Video games	Consumers (consoles)	Software developers
Operating systems	Applications developers	Clients
	(b) Portals and media industries	
Newspapers	Readers	Advertisers
	(c) Payment system industries	
Credit cards	Cash holders	Merchants
	(d) Other industries	
(Legacy) Internet	Web sites	Dial up consumers

Table 2: Socio-demographics

(a) Gender

	Male	Female
Ratio	63.2%	36.8%

(b) Age

	20s and uner	30s	40s	50s and over
Ratio	14.1%	21.8%	27.7%	36.4%

(c) Occupation

	Self-employed	Office worker	Parttime worker	University Students	Housewife	No occupation	Others
Ratio	15.8%	57.9%	7.8%	1.5%	9.3%	6.3%	1.0%

(d) Annual household income class

	JPY1M<	JPY1-3M	JPY3-5M	JPY5-7M	JPY7-10M	JPY10-15M	<JPY15M
Ratio	4.2%	13.0%	26.7%	22.8%	21.5%	10.3%	1.5%

Table 3 Fixed-line Internet market share

(a) Type of Internet access line

	ADSL	FTTH
Ratio	38.7%	61.3%

(b) ADSL market share

	NTT	KDDI	Softbank
Ratio	36.2%	0.0%	63.8%

(c) FTTH market share

	NTT	KDDI	Softbank
Ratio	82.0%	17.0%	1.0%

Table 4: Fixed-line broadband usage

(a) ADSL Internet usage (multiple answers)

	E-mail	Web browsing	050-IP phone	0ABJ-IP phone	Security	Online game	Online shopping	Net banking
Ratio	95.4%	67.4%	37.5%	2.6%	45.7%	18.1%	82.2%	69.1%

	Free music	Pay music	Free movie	Pay movie	Other free contents	Others
Ratio	24.6%	5.2%	44.4%	2.0%	3.0%	0.3%

(b) FTTH Internet usage (multiple answers)

	E-mail	Web browsing	050-IP phone	0ABJ-IP phone	Security	Online game	Online shopping	Net banking
Ratio	97.3%	66.0%	15.4%	10.0%	46.6%	13.3%	80.1%	68.2%

	Free music	Pay music	Free movie	Pay movie	Other free contents	Others
Ratio	25.8%	7.9%	40.5%	2.9%	2.3%	0.0%

Table 5: Mobile phone market share

(a) Type of providers

	NTT	KDDI	Softbank
Ratio	49.2%	25.4%	25.3%

(b) Type of standard

	2G	3G
Ratio	8.8%	91.2%

(c) 2G market share

	NTT	KDDI	Softbank
Ratio	21.7%	44.9%	33.3%

(d) 3G market share

	NTT	KDDI	Softbank
Ratio	51.9%	23.6%	24.5%

Table 6: Mobile phone usage

(a) 2G usage (multiple answers)

	E-mail	Web browsing	Camera	Watch	Picture data	Music data	Game	TV/Radio
Ratio	74%	25%	46%	62%	7%	88%	6%	12%

	TV phone	Movie data	Felica (Wallet)	Wireless	Bar code	Global roaming	GPS	Others
Ratio	0%	0%	10%	12%	10%	0%	9%	0%

(b) 3G usage (multiple answers)

	E-mail	Web browsing	Camera	Watch	Picture data	Music data	Game	TV/Radio
Ratio	89%	53%	63%	66%	29%	80%	20%	26%

	TV phone	Movie data	Felica (Wallet)	Wireless	Bar code	Global roaming	GPS	Others
Ratio	10%	9%	19%	34%	28%	4%	13%	0%

Table 7: Theoretical extensions of two-sided market models

Paper	Problems	Results
Doganoglu and Wright (2006)	Which is better in two-sided markets, compatibility or multihoming?	Multihoming weakens competition and introduces costs that firms do not internalize.
Hagiu (2006)	What is the pricing and commitment in two-sided markets when platforms are essential bottleneck inputs?	A monopoly platform prefers not to commit to a price when it announces the price if it faces unfavorable seller expectations.
Guthrie and Wright (2007)	How does competition between identical schemes affect the choice of fee structure in two-sided markets?	While competition between schemes lowers equilibrium interchange fees, competition between merchants increases them.
Armstrong and Wright (2007)	What happens in two-sided markets when platforms are viewed homogenously by sellers but heterogeneously by buyers?	Platforms do not compete directly for sellers and instead choose to compete indirectly by subsidizing buyers to join.
Kind, Koethenbuerger, and Schjelderup (2008)	What is the efficient provision and optimal taxes of goods in two-sided markets?	Imposing negative value-added taxes or positive specific taxes can reduce the output.
Bolt and Tieman (2008)	Why are price markups frequently much higher on one side than the other?	The most elastic side of the market generates maximum demand by providing it with platform services at the lowest price.
Rochet and Tirole (2008)	What is a tying-in in two-sided markets in payment card associations through the so-called honor-all-cards (HFC) rule?	The HFC rule not only benefits the multi-card platform but also raises social welfare due to a rebalancing effect.
Ambrus and Argenziano (2009)	How much is externality valued in multiple asymmetric networks?	One network is cheaper and larger on one side, while the other network is cheaper and larger on the other side.
Belleflamme and Toulemonde (2009)	What happens if agents value the presence of the agents of the other type but negatively value the presence of the agents of their own type?	A new platform cannot be subsidized to divert agents from the existing platform if intra-group negative externalities are strong.
Reisinger, Ressner, and Schmidtke (2009)	How do differentiated platforms compete in advertising levels and offer consumers a free service that is financed through advertising?	Advertising exhibits the properties of a strategic substitute or complement, and platform profit increases with market entry.
Ellman and Germano (2009)	How do newspapers sell news to readers who value accuracy and sell space to advertisers who value advert-receptive readers?	Monopolistic newspapers under-report news that sufficiently reduces advertiser profits; increasing the size of advertising eventually leads competing newspapers to reduce advertiser bias.
Galeotti and Moraga-Gonzalez (2009)	Does a platform attract firms selling differentiated products and buyers interested in those products?	When product differentiation raises the value of the platform for the consumers but weakens competition, the platform raises both charges to consumers and fees for firms.

Table 8: Empirical extensions of two-sided market models

Paper	Object	Findings
Rysman (2004)	Two-sided markets for Yellow Pages in America	Advertisers value consumer usage while consumers value advertising, implying that internalizing network effects would significantly increase surplus.
Rysman (2007)	Two-sided markets for payment card industry in America	A regional correlation exists between consumer usage and merchant acceptance within the four major networks (Visa, MasterCard, American Express, and Discover), which suggests a positive feedback loop.
Kaiser and Wright (2006)	Two-sided markets for magazine readership and advertising in Germany	Magazines have properties of two-sided markets, implying that higher demand on the reader side increases ad rates, but higher demand on the advertising side decreases cover prices.
Argentesi and Filistrucchi (2007)	Two-sided markets for newspaper industry in Italy	A comparison between the estimated markups and the observed markups shows evidence of joint profit maximization on the newspaper cover price, but the advertising market is closer to competition.

Table 9: Basic statistics

	NTT	Softbank	KDDI	Total
User number of fixed-line Internet	505	199	82	786
User number of mobile phone	387	199	200	786
Monthly basic price: Fixed-line (JPY)	4134.2	4113.1	5056.8	4239.7
Monthly basic price: Mobile phone (JPY)	2725.6	2107.9	3424.2	2573.8
User number of ADSL	110	194	0	304
Carrier brand integrating users	270	64	30	364

Table 10: Estimation results

(a) Fixed-line Internet

Sample No.	786
Log likelihood	-574.5943
McFadden R2	0.15762

Variable	Estimates	t value	
Fixed-line Price	-0.00023	-4.122	***
Mobile Network Effects	3.95510	4.050	***
NTT ADSL	-2.17973	-11.402	***
NTT AGE	0.02122	2.636	***
NTT SHOPPING	0.52433	1.724	*
SB IPPHONE	1.01601	3.245	***

Note: *** 1% significance, ** 5% significance, * 10% significance

(b) Mobile Phone

Sample No.	786
Log likelihood	-803.3217
McFadden R2	0.02187

Variable	Estimates	t value	
Mobile Price	-0.00015	-4.200	***
Fixed-line Network Effects	1.17350	5.226	***
NTT Music	-0.54355	-2.220	***
NTT GPS	-0.43926	-1.726	*
SB Music	-0.70770	-2.370	**
SB GPS	-0.75960	-2.388	**

Note: *** 1% significance, ** 5% significance, * 10% significance

Table 11: Marginal effects

(a) Fixed-line Internet Marginal Effects

	NTT Fixed-line Price	SB Fixed-line Price	KDDI Fixed-line Price	NTT Mobile Network Effects	SB Mobile Network Effects	KDDI Mobile Network Effects
NTT Fixed-line Marginal Effects	-.0041 ***	.0027 **	.0014 **	68.8940 ***	-45.4297 **	-23.46433 **
SB Fixed-line Marginal Effects	.0027 **	-.0035 **	.0008	-45.4297 **	58.8485 **	-13.4188 **
KDDI Fixed-line Marginal Effects	.0014 **	.0008	-.0022 *	-23.4643 **	-13.4188	36.8830 *

Note: All figures multipied by 100. *** 1% significance, ** 5% significance, * 10% significance.

(b) Mobile Phone Marginal Effects

	NTT Mobile Price	SB Mobile Price	KDDI Mobile Price	NTT Fixed-line Network Effects	SB Fixed-line Network Effects	KDDI Fixed-line Network Effects
NTT Mobile Marginal Effects	-0.0037 ***	0.0018 ***	0.0018 ***	28.237 ***	-14.0982 ***	-14.1388 ***
SBMobile Marginal Effects	0.0018 ***	-0.0029 ***	0.001 **	-14.0982 ***	22.0079 ***	-7.9097 ***
KDDI Mobile Marginal Effects	0.0018 ***	0.001 **	-0.0029 ***	-14.1388 ***	-7.9097 ***	22.0485 ***

Note: All figures multipied by 100. *** 1% significance, ** 5% significance, * 10% significance

Table 12: Price structures of two-sided markets

(a) Markup of Fixed-line Internet

	Price Effect		Mobile Markup		Network Effect		Markup
NTT	15,671	+	1,027	*	-0.4235	=	15,236
Softbank	7,234	+	3,077	*	-0.3469	=	6,167
KDDI	4,742	+	7,552	*	-0.3392	=	2,180

Note: Figures represented by JPY

(b) Markup of Mobile Phone

	Price Effect		Fixed-line Markup		Network Effect		Markup
NTT	13,297	+	15,236	*	-0.8053	=	1,027
Softbank	8,730	+	6,167	*	-0.9167	=	3,077
KDDI	8,774	+	2,180	*	-0.5607	=	7,552

Note: Figures represented by JPY